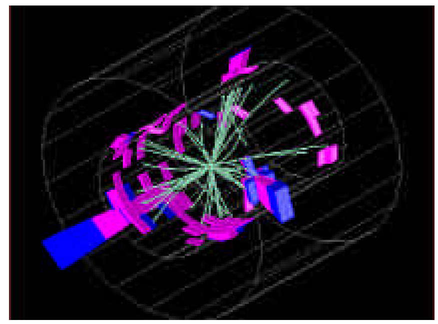
High Energy Physics

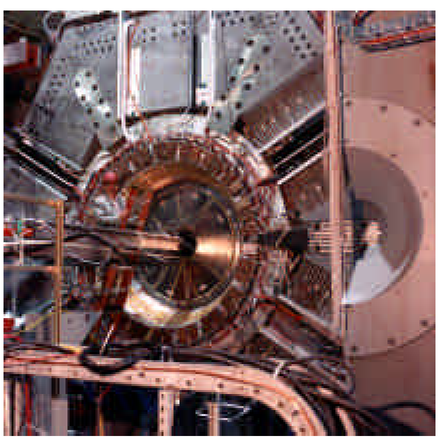
http://www.sc.doe.gov/production/henp/henp.html

The High Energy Physics (HEP) program studies the basic constituents of matter and their interactions. In FY 2002, the U.S. High Energy Physics program is being realigned to take advantage of unique opportunities that have developed in the past year for history-making discoveries.

The Opportunity: The Large Electron-Positron Collider at CERN in Switzerland was shut down in November 2000, leaving behind a tantalizing hint of a Higgs boson with a mass that is well within reach of the Tevatron at Fermilab, which collides protons and antiprotons. The Higgs boson is believed to be the source of mass for all elementary particles, and its discovery would be a profound advance in physics. The Large Hadron Collider (LHC) now being constructed at CERN will be a strong contender to find the Higgs, and American physicists will participate in that research; but it cannot begin an active physics program before the spring of 2006. Thus the Tevatron will have an opportunity to make this important discovery before the LHC can get fully underway. This collider with its two detectors have just finished major upgrades and began operating in March 2001 with higher energy and data-taking capability than ever. With protons and antiprotons colliding head-on at energies of a trillion electron volts (1 TeV), the Tevatron will be the world's highest energy physics research facility for the next five years.



Simulation of a Higgs boson event as it might appear in CDF



The BaBar detector at the B-Factory

At the Stanford Linear Accelerator Center (SLAC), the B-Factory and its BaBar detector will have an opportunity to explain the vast preponderance of matter over antimatter in the universe by studying B mesons. Electrons and positrons colliding at energies of several billion electron volts will allow the study of an asymmetry in the way B mesons decay into other particles. The asymmetry is known as Charge-Parity (CP) violation and was first discovered in 1964. Still not fully understood, CP violation is believed to be at least partly responsible for the survival of more matter than antimatter after the Big Bang origin of the universe. The question is whether it provides the entire explanation or is there some additional, unknown cause. Investigating this important asymmetry will also extend our understanding of elementary particles.

Continued

In early 2001, a very precise measurement of the anomalous magnetic moment of the muon was reported, the first result from a dedicated experiment at Brookhaven's AGS proton accelerator. The measured value differed from theoretical predictions. If this early result holds up after more data is analyzed, it will indicate that there is new physics to be discovered, beyond our current understanding of elementary particles and interactions.

A long baseline neutrino detection experiment called MINOS is currently being assembled at Fermilab, and a dedicated beam of neutrinos is being built for it. With this new facility, Fermilab will have the opportunity to confirm early indications that the neutrino has a small mass and, if it does, to make precise mass measurements. Our current theory assumes that neutrinos have no mass at all. Positive results from MINOS would require that the theory be modified and would help to explain at least part of the dark matter in the universe.

The Challenge: In order to find the Higgs boson, the Tevatron must run extensively and increase its luminosity (which determines the data rate) substantially. This requires a program of improvements to be carried out from FY 2002 to 2005, interleaved with intensive data runs. The Tevatron is expected to operate for about 39 weeks in FY 2002 and the luminosity should be improved by a factor of ten by 2005.

The B-Factory will need a progressive series of upgrades in order to be competitive with a similar facility now operating in Japan that has three times more design luminosity. Improvements to B-Factory luminosity are planned in a series of steps to be executed over three years (FY 2002-2004). Because of the potential importance of the g-2 experiment, it will need more running time in 2002, and the MINOS detector and beam must be completed.

FY 2002 Investment Plan: In FY 2002 the Office of Science will focus its efforts primarily on the major opportunities summarized above. Funding priorities will go to operation and improvements at the Tevatron and the B-Factory as well as to university groups working at those facilities. Lower priority will be given to the g-2 experiment, the NuMI/MINOS project, and the remainder of the research program.

The Benefits: The High Energy Physics program has a chance to make physics history with major advances. Discovering the Higgs boson would explain how all elementary particles, and hence all forms of matter in the universe, acquire mass. Studies of CP violation in B mesons would help us understand why our universe is composed almost exclusively of matter rather than containing some antimatter. Studies of the neutrino could have a substantial impact on our understanding of elementary particles and explain part of the mysterious dark matter that makes up most of the universe. The unique DOE research facilities and strong research program in high energy physics will help the United States to maintain its pre-eminent position in this field of knowledge, help to educate our brightest young people in science, and transfer to industry the useful technologies often developed for research.